

MINNESOTA ENGINEERING PROCEDURE

EMBANKMENT RESERVOIRS AND STRUCTURES

This procedure applies in general to all structures and ponds. Detailed requirements set forth in this procedure will not apply to Class V ponds, sod chutes, toe walls and simple surface water pipe inlets to open ditches.

Before Construction**A. Job Investigation**

1. Purpose and use.
2. Adaptability of site and hazard classification.
3. Soils and existing natural vegetation.
4. Approximation of watershed size and characteristics.
5. Type and location of structure to best serve needs.
6. Characteristics of outlet.
7. Construction problems.
8. Consider cost of structure in relation to benefits derived.
9. Operation and maintenance.
10. Safety consideration (refer to General Manual).
11. Consider the need for complimentary conservation practices.

B. Design Survey

1. The type of survey will depend on the type of structure contemplated and the surveying equipment available. All surveys are to contain the following:
 - a. At least one good bench mark that will not be destroyed during construction. If this cannot be located at the site, a temporary bench should be set near the proposed works of improvement. The datum should be tied to mean sea level whenever possible, especially for the larger structures.
 - b. A good sketch.
 - c. A profile downstream from the structure outlet for at least 500 feet to show whether a stable grade exists. This may be reduced to 300 feet for structures that will have a cantilever outlet.
 - d. Typical cross sections at critical locations below the structure are to be taken for 400 to 500 feet for tailwater calculations. At least two cross sections will be taken at restricted channel sites to allow an approximate determination of tailwater depth and the velocity of flow in the discharge channel. In cases where there is a question as to the stability of the grade below the structure, such cross section shall be taken every 200 to 400 feet for as far as necessary to determine adequately the allowable grade below the structure.

Cross sections taken for velocity and depth of flow determinations need to be extended only to beyond the maximum probable wetted perimeter. It is not necessary to run the cross sections to the top of bank unless the banks are apt to overflow. A description of the soil and vegetative cover will be recorded at appropriate cross sections.

When propped outlets are to be used, only cross sections required for the design of the propped outlet and any necessary channel change need to be taken.

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Cross sections are also to be taken just above highway bridges, culverts and other structures that affect or are affected by the installation of the proposed work showing:

- (1) Flow line elevations and other pertinent elevations and data for the bridges, culverts, or other structures.
- (2) A cross section along the centerline of the road or earth fill over the bridge or culvert which should be extended to include the lowest point along the centerline.

Cross sections where the proposed structure is attached to an existing culvert or bridge will be accompanied by a detail sketch showing elevations and dimensions of the existing structure.

- e. Watershed boundary accurately located and characteristics determined. Aerial photographs, USGS quadrangle sheets or digital elevation models should be used for this purpose. Field verify as needed.
- f. Soil boring logs as needed for design with location and elevations being tied into surveys.
- g. Location of fences, property lines, and physical features that might affect design.
- h. Notes showing closure to original bench mark.
3. Additional requirements of cross section profile type survey:
 - a. Baseline must be established so cross sections and profiles are tied in.
 - b. Sufficient cross sections should be taken so that adequate information is available for design of all planned works of improvement. If permanent or temporary storage is involved, cross sections are to be taken of the pool area. All cross sections are to be taken close enough together so that contour lines can be drawn.
 - c. See Figure 2-2 of Technical Release No. 62 for example of survey notes. These notes show cross sections perpendicular to the centerline of the earth fill. These are not necessary when the earth fill yardage figures are used only for estimating purposes unless the site is very irregular.
4. Additional requirements of the topographic survey. This type of survey is very desirable for structures that store water or sediment.
 - a. Rod shots must be close enough together so that contours of the desired interval can be drawn.
 - b. Rod shots should be taken on physical features and landmarks in the vicinity that will orient the survey and make it possible to relocate any survey points at a later date.
 - c. Horizontal control should be closed.

C. Design

Design will be in accordance with Minnesota Practice Standards 350, 378, 402 and 587, whichever is applicable.

D. Preparation of Plans

A design folder is to be prepared for all Class IV and V jobs. The folder is to contain the investigations, notes, computations, drawings, sketches, and other data used in the design analysis, the construction drawings, specifications, bid schedule (if prepared) and plan for operation and maintenance. The items are to be recorded neatly and organized in a folder or binder (or referenced if too large to be included) to keep them in order. Investigations and design documentation for all class jobs are to be neatly organized so that they may be efficiently reviewed at any stage.

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Normally the plans (drawings and specifications) are to be prepared in a manner and format that provides all the information needed to construct the works of improvement. Other material, such as design data and calculations should only be included on the drawings if it will not unnecessarily complicate the drawings or confuse the individuals using the drawings during construction or checkout.

1. Size of Data Sheets

Appropriate plans are to be prepared for all jobs prior to construction. The information required to meet data sheet needs varies with the type, size and site of the job. The smaller jobs, normally Class I and II may be put on "N" size data sheets

The larger, more complex jobs should be put on Standard "E" size (21"x30") or "D" size data sheets.

2. Gully or Channel Profile

- a. Scale. The profile is to be plotted on profile paper, using a horizontal scale of 1"=20, 40, 80, 100, 200 or 400 feet and a vertical scale of 1"=4, 8 or 10 feet.
- b. Stationing will be shown in the direction of stream flow unless the structure is part of a drainage design. Station numbers are to be selected large enough to avoid possible future negative stationing. It is standard practice to name banks right and left looking in the direction of increasing stations.
- c. An accurate bottom profile, including lateral channels, is to extend upstream from the structure site at least to a point where the elevation is the same as the maximum stage to which water will rise above and below the structure to a stable grade as determined by velocity computations. However, when propped outlets are used, the profile below the structure may be terminated when the length of profile shown is adequate for the design of the propped outlet (minimum distance 100 feet).
- d. A profile of the top of the gully banks. Where bank tops are at approximately the same elevation on both sides of the channel, an average top-of-bank profile may be shown and indicated as such. Along excavated channels with spoilbanks, profiles of the top of the spoilbank and of the natural ground line outside the spoilbank are to be shown.
- e. The location of the proposed structure. The structure must be shown on the profile at the correct station and elevation. The following elevations are to be clearly shown and labeled:
 - (1) Crest of mechanical spillway.
 - (2) Top of outlet apron or invert of pipe spillway at the outlet.
 - (3) Top of headwall extension or high concrete on spillway inlet.
 - (4) Water surface at maximum stage of design storm.
 - (5) Top of earth fill (settled height).
 - (6) Crest of emergency of vegetated spillway.
- f. The location, elevations and dimensions of pertinent existing structures such as bridges, culverts, floodgates, tile outlets, etc. In the case of bridges, culverts, floodgates, etc., the profile is to show by note the length of structure, the cross sectional dimensions the fill over the structure. The elevations of the invert at inlet and outlet on all tile entering the ditch or gully are to be shown.

The following method is to be used to station the locations of proposed structures. The station number shown for chutes, drop inlets, culverts and bridges will be the centerline of the fill or centerline of the roadway. The station number shown for drop spillways, box inlets, or box inlet drop spillways will be the upstream face of the headwall.

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- g. Stationing of fences that cross the drainageway (especially property line fences) shall be indicated and labeled as such.
- h. The location and elevation of springs, ground water seepage, wells, etc., that might affect the location or stability of the structure or be affected thereby, are to be shown. The location and elevation of high water marks will be shown where they are required for the design.

3. Watershed Map

Location and watershed maps are to be shown on all types of structural engineering plans. The map scales will be 1"=330, 400, 500, 600, 1,000, 1,320 feet or on such a scale to confine map to one "E" size sheet. Bar scales will be used. The map should show:

- a. Outline of the watershed boundary.
- b. The drainage pattern.
- c. The names of the owners and others affected by the proposed work.
- d. Location of the proposed work.
- e. Location of bridges, culverts and other structures that affect the flow of water.
- f. Location of roads, property lines and fences.
- g. Location of the section corners and section centers or a legal description of the quarter section in which the structure is located.
- h. North arrow.

The size of the drainage area, soil descriptions, and other items relating to the map are to be tabulated near the watershed map.

4. Cross Sections

Cross sections will be plotted as viewed looking in the direction of increasing stations, on cross section paper (10x10 to the inch). The profile station for each cross section plotted should be centered directly below the cross section on the data sheet. Where the top width of the cross section is not greater than 280 feet, the cross section will be plotted to the same horizontal and vertical scale, thereby giving an undistorted cross section. In such cases, the horizontal and vertical scales should be either 1"=5 feet, or 1"=10 feet. Where the top width exceeds 280 feet, the horizontal scale must be altered to get all of the cross section on one sheet; in such cases the vertical scale will be 1"= 5 feet, or 1"= 10 feet; and the horizontal scale will be 1"= 20 feet or 1"= 50 feet. Where possible, the base line will be set at "0" on the cross section and aligned vertically on the cross section sheet.

- a. Give the cross section information along the centerline of the proposed earth fill showing:
 - (1) Elevation and important dimensions of the principal spillway in proper relation to the cross section showing the elevations of crest, apron and top of weir or headwall.
 - (2) The top of the earth fill at the settled height by a solid line and at constructed height by a dashed line.
 - (3) The elevation of earth fill berms, if any.
 - (4) The elevation and dimensions of vegetative or emergency spillways used.
 - (5) The location of soil borings taken along or near the centerline of the proposed structure. The kind of soil material and water table, with date, found in the test holes shall be indicated in the boring log according to standard legends. All soils information on the plans will be based on the unified soil classification system.

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- b. Cross sections at critical locations below the structure for at least 400 to 500 feet. When propped outlets are used, only cross sections required for the installation of the propped outlet and any necessary channel change need be shown.
 - c. Cross sections just above highway bridges, culverts and other structures that affect or are affected by the installation of the proposed work showing:
 - (1) Flow line elevations of the bridge, culvert, or other structures.
 - (2) A cross section along the centerline of the road or earth fill over the bridge or culvert which should be extended to include the lowest point along the centerline.
 - (3) Other pertinent elevations or data.
 - d. Cross sections where the proposed structure is attached to an existing culvert or bridge accompanied by a detail plan showing:
 - (1) Elevations.
 - (2) Dimensions of existing structures.
 - e. Cross section at control section of earth spillway and typical cross section of inlet channel and exit channel.
5. Location Plan.
The location plan is to indicate and adequately describe the lines of survey (such as Traverse, Reference or Base Lines) and key cross section lines with corresponding station numbers. The plan will contain an accurate contour map of the structure site. The scale may be 1"= 10, 20, 30, 40 or 50 feet. Where this map is shown on a plan profile sheet, the plan scale, if practical, should be the same as the profile; i.e., 20 or 40 feet to the inch. The contour interval is to be one or two feet and in most cases not exceed five feet. The location plan will show in detail:
- a. The spillway and fill locations, referenced to control lines or hubs (to include earth spillway(s), if part of the design). Give necessary dimensions or data for construction layout.
 - b. An outline of the gully or channel bottom and banks.
 - c. All bench marks (with descriptions), hubs, soil borings, borrow areas, fences, buildings, roads, bridges, springs, wells, utilities or other improvements that influence the design or construction of the proposed work.
 - d. Location of a section center or quarter section corner and legal description shall be given.
 - e. Property lines and names of property owners.
 - f. North arrow and bar scale.
6. Where structures include temporary or permanent storage in their design, the following additional information will be required.
- a. Contour Map of Flooded Area. The scale of this map may be 1"= 10, 20, 30, 40 or 50 feet where it can incorporate the details of the location plan or 1"= 100 to 200 feet where a separate location plan is included. The size, as determined by the scale and required details, may vary from a one sheet combination of all maps and the profile, to an individual sheet for this map alone. The object of this map is to indicate with reasonable accuracy:
 - (1) Contour of the area permanently flooded below the crest of the mechanical spillway at a maximum contour interval of 5 feet when needed for design, and
 - (2) Contours of the area temporarily flooded by spillway storage above the elevation of the crest of the principal spillway. These contours generally shall be on a two foot vertical interval.

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- b. Flood Routing Curves and Computations. Flood routing for storage type structures are to follow the requirements of the current flood routing procedures. Computations and derivations will be tabulated on computation sheets and attached to the computer printouts or attached to the computation for short cut flood routing procedures. Short cut flood routing procedures may be used for structures with a watershed area of less than 250 acres. Supporting data will include:
- (1) Figures or data showing preliminary size of structure or conduit and length.
 - (2) Available temporary storage as computed from the contour map.
 - (3) Short cut storage formula and data if used.
 - (4) Computer printouts if used.
 - (5) A completed worksheet MN-ENG-27, Documentation for Hazard Classification.
7. Hydraulic and Hydrologic Data. The following shall be clearly shown on the drawings or included in the design folder:
- a. Runoff and design storm frequency and duration (methods and assumptions shall be indicated or referenced).
 - b. Structure discharge capacity:
 - (1) Principal spillway
 - (2) Emergency spillway
 - c. Tailwater depth.
 - d. Velocity in channel below the structure, except for propped outlets.
 - e. Capacity of bridges, culverts, or other structures affecting or affected by the proposed work.

Methods of arriving at the above figures are to be shown on the plan, or included in the design folder.

8. Section along Centerline of Structure.
An enlarged longitudinal section or profile along the centerline of the proposed structure showing elevations of the ground line and a scaled outline of the structure accurately located according to station and elevation. This profile shall be plotted on cross section paper at a true scale (same scale horizontally and vertically) of 1"= 5 feet, or 1"=10 feet (the former is preferred).
- a. This profile must be tied into the profile of the main gully channel or base line.
 - b. If standard drawings are used to complete the details of the structure, this drawing will act as the layout drawing for construction and will show elevations of:
 - (1) Top of settled fill and berms.
 - (2) Crest of principal spillway.
 - (3) Top of well or apron floor.
 - (4) Outlet and inlet inverts of pipes.
 - (5) Earth spillways.
 - (6) Other elevations pertinent to the control features of the works.
 - c. Accurate stationing is to be indicated on the profile of the structure layout for the centerline of the fill.
 - d. Complete dimensions will locate the following parts of the spillway:
 - (1) Upstream face of the headwall.
 - (2) Outlet and inlet end of pipes.
 - (3) All intermediate controls; (i.e., anti-seep collars, headwall extensions, etc.) and changes of grade in the structure.

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- e. The complete layout is to show:
 - (1) Fill slopes and indicate fill lines (which should be true projections onto a vertical plane through the centerline of the structure).
 - (2) Width of top of fill or roadway and berms.
 - f. A section profile should also be shown along the centerline of the earth spillway showing length of level section, gradient of channel bottom and original ground level.
- 9. Bill of Material. Show quantities, size, and kind of all materials needed for construction in tabular form.
 - 10. Cost Estimate. The estimated cost of the project will be itemized on a separate sheet and included in the design folder.
 - 11. Structure Details. Appropriate drawings will be included showing details for all structural designs.
 - 12. Legends. A legend will be made a part of all plans. An appropriate legend will be drawn on one of the data sheets.
 - 13. List of work to be done. A list of work to be done shall be included as part of the plan; either listed on the drawings or included as a preface to the specifications.
 - 14. Pertinent Notes.
 - a. Information needed to clarify any unique circumstances.
 - b. Dates of revision.
 - c. Construction notes as may be necessary with references to applicable construction specifications.
 - d. Erosion controls necessary to meet NPDES requirements.
 - 15. Data Sheets submitted to State Office for special design jobs may be needed to show the following additional information:
 - a. Cross sections at approximately 50 foot intervals (or at intervals deemed necessary to provide sufficient information for design) above the centerline of fill, extended upstream to maximum high water elevation. These sections are to facilitate the design of the approach channel, and should show the ground line elevation to the maximum stage of the water above the crest of the spillway. These cross sections are to be referenced to the base line.
 - b. Cross sections taken perpendicularly to the centerline of the proposed fill will aid in determination of the amount of fill. These cross sections will be taken at 50 foot intervals and at additional points necessary to accurately compute earth fill volume.
 - c. Cross sections taken across earth spillways from a reference line at such intervals as to enable the designer to plot channel grades and determine relative location and construction details.
 - d. Cross sections taken at a minimum of 200 foot intervals to determine velocity and depth of flow. These are to be continued until the gully or channel outlets into a main channel of stable grade or, if questionable, a minimum of 1,000 feet below the structure site. The channel below the structure shall be described sufficiently to determine an approximate value of Manning's "n". Indicate the kind of soil and vegetation existing on the wetted perimeter of the channel; i.e., large boulders, gravel, sand, silt or clay, with no vegetation, grass, willows, etc.
 - e. Design and construction notes:
 - (1) Give sufficient notes to clarify and explain design and construction details not shown on the data sheets.

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- (2) Give adequate references to all materials (other than that contained in the Engineering Field Handbook supplement) that has been used as an aid in the design of the structure.

Construction**A. Construction Layout**

1. Field layout will be in accordance with the plans except for necessary changes that have been authorized by someone having proper approval authority. If changes are made they are to be recorded on the as built plans.
2. All earth fills are to be sloped staked. Slope stakes should be offset a specified distance so as not to be disturbed during construction. Centerline stakes should be set on the abutments off the construction area.
3. Slope stakes, offset reference hubs for cuts to grade line, and centerline stakes shall be set for the earth spillway
4. Offset reference hubs and centerline stakes shall be set for a pipe spillway.
5. Reference hubs and location stakes shall be set for all drop spillways.
6. Follow appropriate examples in Technical Release No. 62.
7. Furnish the contractor and/or cooperator with a set of plans for Class II or higher jobs prior to construction. Copies of plans for smaller jobs should be furnished as needed. Make sure the contractor has applicable construction and material specifications.

- B. Inspection of Construction. NRCS personnel will inspect construction to the fullest extent possible. Field notes should be kept as part of the performance check. Training of contractors is desirable so that they may perform and keep adequate records of construction checks. Worksheet MN-ENG-50, Certification Statement, should be used to obtain the contractor's certification where work is done during the absence of the NRCS technician.

After Construction**A. Checking**

1. Make visual inspections of completed structure.
2. Determine that adequate survey field notes, plans, specifications and construction layout data are available as a basis for comparing completed work with planned or specified work.
3. Record the performance check in the field notebook according to the National Engineering Manual. As much checking as possible should be done during construction so errors may be corrected before completion.
4. Embankments.
 - a. Profile along centerline of top of completed embankment.
 - b. At least one cross section of completed embankment showing top width and side slopes. This would normally be taken near the deepest part of the fill or at the location where the fill appears least likely to meet specifications.
5. Vegetated Spillways.
 - a. Profile along centerline of completed spillway.
 - b. One or more cross sections of spillway as needed to determine whether planned grade and dimensions were met.
 - c. Statement as to condition of vegetation.
6. Principal Spillway
 - a. Pipe drop inlets

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- (1) Dimensions of completed riser and barrel and kind of material.
 - (2) Elevation of crest of riser and invert of barrel at inlet and outlet end.
 - (3) Size and kind of anti-vortex device.
 - b. Hooded inlet
 - (1) Dimensions of hood, size and kind of pipe.
 - (2) Elevations of invert of pipe at inlet and outlet.
 - (3) Size and kind of anti-vortex device.
 - (4) Scour hole protection.
 - c. Reservoir area
 - (1) Cross sections of reservoir area if enlargement was planned for needed ratio of minimum depth area to pond surface area.
 - (2) Statement as to whether needed fencing and clearing was done satisfactorily.
 - d. Drop spillways, chutes and similar structures. Measurements and elevations of the completed structure as required to show that planned dimensions, elevations and quantities were obtained in construction.
7. Statement that required certificates showing material are certified as meeting specifications have been obtained. Show contractor's name.
8. Statement indicating any items that did not meet drawings or specifications.
9. Statement as to certification, signature and date.

B. As-Built Plans

This is not to be a new plan. It is merely the correcting or noting of any changes made during construction on a copy of the plan prepared prior to construction. As-built changes are to be shown on a set of the approved drawings in red pencil and initialed and dated by the individual approving the change.